ERDC/CERL TR-06-15

Construction Engineering Research Laboratory

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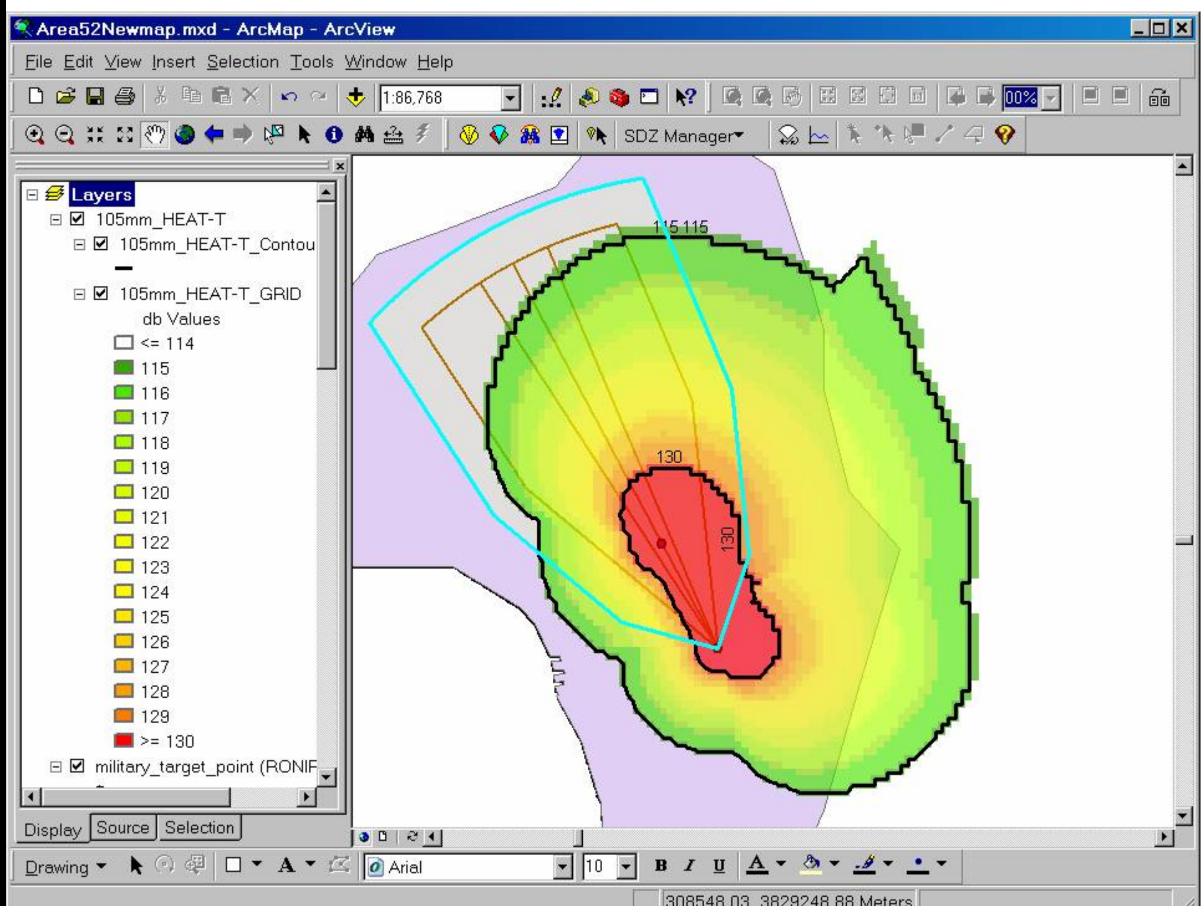
The Range Managers Toolkit (RMTK) Noise Tool

Michelle E. Swearingen

June 2006



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Final Report

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Abstract: The Range Managers Toolkit (RMTK) Noise Tool is a noise prediction and impact assessment software tool designed to enable installation Range Control offices to quickly assess the noise impact of military training or testing at a specified site under a variety of weather conditions, and to plan preliminary range siting for noise. The noise model outputs a map display that designates acoustic regions in decibels and by color. This work documents and summarizes the scientific basis for noise complaint risk criteria, weather cases, and time-on-target assessment.

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Preface

This study was conducted as part of the Training and Testing Noise Control Environmental Quality Technology (EQT) program under Project D048, "Industrial Operations & Pollution Control Technology," Work Unit 3K8294, "New Noise Prediction Tools." The final *RMTK Noise Tool* was ultimately supported by ERDC 6.1 and 6.2 funds, reimbursable funds from the Army Sustainable Range Program (SRP) program, and leveraged funds by the Army SRP program to provide the geographic information system (GIS) interfacing and the graphical user interface (GUI). The technical monitor was Dr. William Russell, U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM), MCHB-TS-EEN.

The work was performed by the Ecological Processes Branch (CN-N) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Michelle E. Swearingen. Alan Anderson is Chief, CEERD-CN-N, and Dr. John Bandy is the Chief, CEERD-CN. The associated Technical Director was William Severinghaus. The Director of CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL James R. Rowan, and the Director of ERDC is Dr. James R. Houston.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(5/9) x (°F – 32)	degrees Celsius
degrees Fahrenheit	(5/9) x (°F – 32) + 273.15.	kelvins
feet	0.3048	meters
gallons (U.S. liquid)	0.003785412	cubic meters
horsepower (550 ft-lb force per second)	745.6999	watts
inches	0.0254	meters
kips per square foot	47.88026	kilopascals
kips per square inch	6.894757	megapascals
miles (U.S. statute)	1.609347	kilometers
pounds (force)	4.448222	newtons
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square miles	2,589,998	square meters
tons (force)	8,896.443	newtons
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

1 Introduction

Background

Noise from military training and testing operations can significantly impact surrounding areas. Community annoyance response to noise, typically in the form of complaints, political pressure, legal action and damage claims, hamper mission execution. One element of an effective noise management strategy is the ability to accurately forecast and assess noise exposure to surrounding areas. The Range Managers Toolkit (RMTK) Noise Tool is a noise prediction and impact assessment software tool designed to enable Range Managers and trainers to quickly assess the noise impact of training or testing on any given day and for a variety of weather conditions, and also to plan preliminary range siting for noise. Output from the noise model is a map display that designates acoustic regions in both decibels (dB) in a PK15(met) metric, and by color to indicate relative levels of complaint risk.

The *RMTK Noise Tool* project began in April 2003 when the RMTK Working Group (WG), chaired by Army Training Support Center (ATSC) and co-sponsored by the Army Sustainable Range Program (SRP) and U.S. Marine Corps (USMC) Training and Education Command (TECOM), contacted the Construction Engineering Research Laboratory (CERL) Noise Team about adding a user-friendly noise assessment tool to the RMTK suite of tools. Coincidentally, the Training and Testing Noise Mitigation, Army Environmental Quality Technology (EQT) Management Plan (ETMP) also contained a project for a similar noise assessment tool called the “Range Operators Noise Impact Predictor” (RONIP). After an August 2003 meeting, the principals of both projects decided to merge the two projects. Consequently, RONIP became the “RMTK Noise Tool.” In this arrangement, funding and expertise were leveraged between the CERL noise team and the Sustainable Range Program (SRP) geographic information system (GIS) community. It was agreed to include large weapon noise prediction in the first software version, and to include small arms at a later date. A May 2005 release date was set at that time.

Work on the project officially started in October 2003. During the first year, initial design was laid out and user support and input were gathered at the Range and Training Land Program (RTLP) Symposium and the Integrated Training Area Management (ITAM) Program Conference. Basic program parameters were decided such as display metric (dB Peak vs. complaint risk), graduated color or blocks of color to represent acoustic regions, supported

weapons, weather cases, and supported training. Researchers also began to adapt the BNOISE2™ calculation engine, update the noise database, and design the graphical user interface (GUI).

During FY05, the tool came together. Although funding delays and development difficulties delayed the program release date until September 2005, alpha testing was completed in May of 2005, after which the *RMTK Noise Tool* was recommended for beta testing. The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Operational Noise Group extensively beta tested the product. Two installations (Twentynine Palms USMC, CA and Camp Atterbury, IN) performed additional testing off-site, which produced valuable information about tool usage and uncovered several critical bugs. At the time of this writing, although no user feedback was available, the SRP GIS Regional Support Centers gave positive feedback indicating that the software was stable and showed no problems. The final step required to complete the product was to document the software and the scientific basis underlying the *RMTK Noise Tool*.

Objective

The objective of this final stage of development was to document the software with a brief walkthrough of software usage and output, and to document the scientific basis for the *RMTK Noise Tool*.

Approach

The CERL and SRP teams collaborated to develop the *RMTK Noise Tool*. The CERL noise team performed research (as detailed in this report), adapted the existing BNOISE2™ calculation engine, and updated the noise database to work within the RMTK framework. The Army SRP provided expertise for the GUI, and interfaced the *RMTK Noise Tool* with the RMTK surface danger zone (SDZ) tool.

Scope

This report documents the background, use, and scientific basis for selected components of the *RMTK Noise Tool*. Information was derived from a collection of the software walk-though help files, the requirements document, a description of the calculation engine and database, and several white papers.

Mode of Technology Transfer

The *RMTK Noise Tool* is available for download on the Army SRP website at Universal Resource Locator (URL):

https://srp.army.mil/

This report will be provided directly to the Operational Noise Program of USACHPPM (the Army technical transfer agent for and primary user of military blast noise technology) and to other known users, and will be made publicly accessible through the World Wide Web (WWW) at URL:

http://www.cecer.army.mil

2 General Description

The *RMTK Noise Tool* is part of the Range Managers Toolkit (RMTK)that provides a noise prediction and impact assessment capabilities in a tool that is both easy to use and simple to interpret. The Noise Tool software runs as an add-in in *ArcMap*,* and is designed to give Range Managers and trainers a simple, quick way to assess the noise impact of training or testing on any given day, for a variety of weather conditions. It is also designed for preliminary range siting for noise. Output from the noise model is displayed in both decibels (dB) in a PK15(met) metric, and as complaint risk, denoted by color.

How the *RMTK Noise Tool* Works

The *RMTK Noise Tool* runs as a module in the Range Managers Toolkit. Because information about firing points, target points, weapons, and munitions are needed for both SDZ generation and noise assessment, the Noise Tool uses existing SDZs. In brief:

1. The user generates an SDZ for a given situation.
2. The user then selects the SDZ with the SDZ selection tool, and then may generate a noise contour.
3. The Noise Tool uses the location and weapon information from the SDZ as well as additional information about the weather conditions, specific weapon platform, and charge zone (if applicable).
4. The combined information is then used by the Annoise calculation engine to calculate the noise levels expected from that particular configuration and condition on a raster grid.
5. This grid is then sent back into RMTK, and displayed on the map in color. The colors describe the likelihood of receiving a noise complaint: green = low risk (PK15=115 dB for large weapons); red = high risk (PK15=130 dB for large weapons); and black contour lines are drawn at these thresholds. The user can then look at the map and quickly determine the likelihood of receiving a noise complaint due to a particular training exercise.

The following walkthrough and output explanation from the *RMTK Noise Tool* on-line was reproduced from *RMTK Noise Tool* help files. The addi-

* ArcGIS is an integrated collection of GIS commercial software products for building a GIS, developed and marketed by Environmental Systems Research Institute, Inc. (ESRI). Complete product information is available through URL: http://www.esri.com/

tional information included in the help files are not included here. The on-line help files are hyperlinked these various additional topics.

Official Use of RMTK Noise

The RMTK Noise Tool is designed to be a day-to-day planning tool for Range Control personnel. The output is designed to give Range Officers a "head's up" on potential noise impacts on both on- and off-post communities based on current or expected weather conditions.

Another potential use for the RMTK Noise Tool is in preliminary range siting. The RMTK Noise Tool can provide preliminary data for range siting considerations. For example, suppose that you are designing a new range. You have two choices for location, A and B. After running the RMTK Noise Tool on each location, both have potential noise problems, but location A appears to have less impact. Because there is potential for noise problems due to this new range, a more detailed analysis is needed and noise mitigation techniques need to be explored. Expertise in noise mitigation techniques and professional-grade noise analysis are available to DoD through USACHPPM's Operational Noise Program (phone: (410)436-3829, URL: http://chppm-www.apgea.army.mil/dehe/morenoise/).

The RMTK Noise Tool does not provide noise mitigation assistance beyond scheduling in terms of both time and location. The RMTK Noise Tool output is not intended for official documents or general public release.

Getting Started

The *RMTK Noise Tool* is a subpart of the RMTK SDZ Tool. The *RMTK Noise Tool* allows users to create and view noise contours. The *RMTK Noise Tool* output has been tested to ensure that it accurately calculates the following noise contours:

- The *RMTK Noise Tool* allows range managers to determine the likelihood of receiving a noise complaint due to training or testing operations, based on weather conditions and the system being trained on or tested.
- The *RMTK Noise Tool* allows users to create and view noise contours and generate a Combined Arms Live Fire Exercise (CALFEX) noise contour.
- The *RMTK Noise Tool* may be used for preliminary range siting.
- The *RMTK Noise Tool does not* offer mitigation advice beyond scheduling.

File and Folder Descriptions

Do not move or delete any of these files or folders:

1. Main SDZ path is *C:\arcgis\SDZ*. This is the path where the files required by the Noise tool are stored: Annoise.dll, dforrt.dll, and msvcrtd.dll.
2. Data path is *C:\arcgis\SDZ\Data\Noise\DB*. All of the files under the data path are required by the Annoise.dll. The subdirectories contain information necessary to generate the noise contours.
3. Noise contours are saved to *[User Selected] \Data\Noise*. Subdirectories contain information for individual cases. This is where case.log, case.txt, and case.err (if a problem occurred). These files must be forwarded to the ITAM GIS Regional Support Center (RSC) in the event of a problem for proper diagnosis and solution.

RMTK Noise Generator

Select an SDZ

A valid SDZ must be selected with the “Select SDZ” Tool. The RMTK Noise Tool currently supports the following weapon classes:

- tanks and fighting vehicles (not grenade launchers)
- artillery and mortars
- grenades (launchers only)
- mines and pyrotechnics (limited number of options)
- rockets
- recoilless or anti-tank.

Noise contours for small arms are not available at this time. Lasers do not generate sufficient noise to merit generating noise contours.

Starting the RMTK Noise GUI

Once you have selected an SDZ using the “Select SDZ” Tool, use the SDZ Manager pull-down menu to access RMTK Noise, and then to select the SDZ *RMTK Noise Tool*. Click on “SDZ *RMTK Noise Tool*.”

RMTK Noise Tool Input

User Parameters Tab

The top block of the “Selected SDZ” menu (Figure 1) is separated into two selection tabs, the “User Parameters, and the “SDZ Summary.” In this example, the “Select RMTK Noise Data Layers” block is grayed out because terrain has not yet been incorporated into the *RMTK Noise Tool*.

Select Firing Scenario Parameters

This block allows the user to choose the propagation conditions. Choose conditions that most accurately reflect the expected weather during scheduled training. If an average weather case is needed, use conditions that are generally accepted as “average” for your installation. For example, your average spring midday conditions may be partly cloudy, with 15 mph winds out of the southwest. To see a worst case scenario (that assumes the strongest propagation conditions in all directions), choose the “Worst Case” options in the pull-down menus.

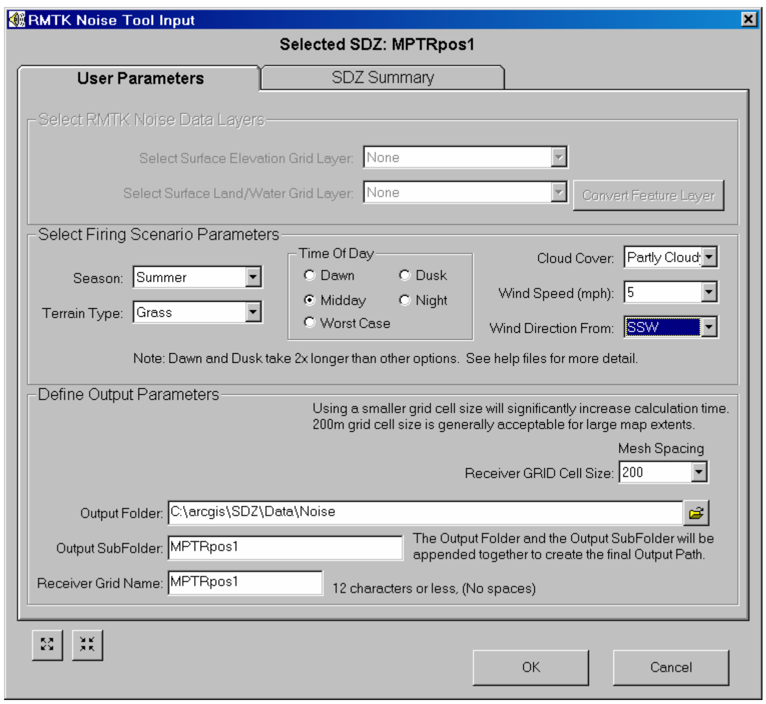

Figure 1. User Input screen in RMTK Noise Tool GUI.

Define Output Parameters

This block allows the user to determine the Receiver GRID Cell Size and the location and name of the output folder and name of the receiver grid. There should be no spaces in the folder or receiver grid names. A large grid extent takes longer to calculate over than a small grid extent. Likewise, if the grid extent is fixed, a smaller grid cell size will take longer to calculate than a larger grid cell size. A grid cell size of 200 (m) is a good balance between speed and accuracy in most cases for large weapon noise. A larger grid cell size is acceptable for large grid extents, but some accuracy is lost. A smaller grid size may be used to more accurately calculate a noise contour, but at the expense of longer calculation time.

The map will auto-zoom to an appropriate map extent. The zoom in and zoom out arrows at the bottom of the tab allow the user to manipulate the map extent. The *RMTK Noise Tool* only performs its calculation in the visible map extent.

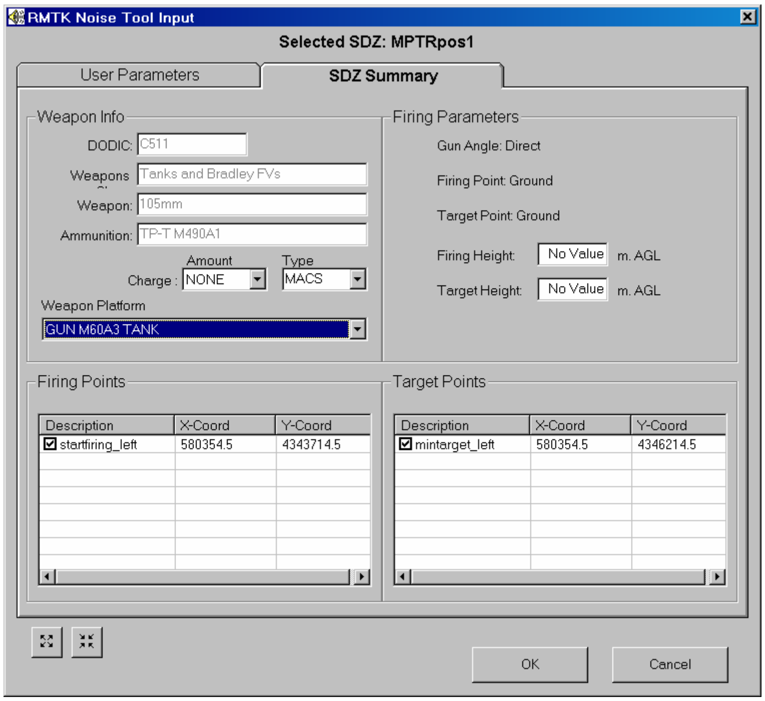

Figure 2. SDZ Summary screen in RMTK Noise GUI.

SDZ Summary Tab

The SDZ summary tab (Figure 2) presents a summary of the Weapon Info, Firing Parameters, Firing Points, and Target Points. In most cases, only one weapon platform exists in the Noise database. In those cases, the Weapon Platform pull-down will auto-populate. If there is more than one option, the user will need to select the appropriate weapon platform from the pull-down menu. In cases where there is no weapon platform available (such as with a demolition charge), or where the user only wants the noise due to ammunition detonation, “NONE” may be selected as the weapon platform. For those weapons that use zone charges, the number and type of charges must be selected as well.

Firing Points and Target Points are selectable via checkboxes. If more than one firing point or target point is available, a Midpoint option will also be available. A noise calculation is performed for each combination of firing point and target point. See also Firing Area and Target Area.

When all of the parameters are set, click on “OK” to run. You will get a message saying “Getting output Grid Info, Please Wait ...” Be patient, and remember that the run time depends on weather case, grid extent and grid cell size, and number of firing and target points. The following section describes the RMTK Noise Output display.

RMTK Noise Tool Output

The output of RMTK Noise depends heavily on the weapon system, projectile, and weather conditions. If the weapon system has some associated acoustic directivity, the projectile can cause a ballistic shock wave to form and create additional noise upon detonation. Weather conditions further complicate the acoustic propagation.

Case 1: 105-mm Stryker, Training Round (inert), No Wind, Midday, Clear Skies

This case (Figure 3) illustrates firing area noise, acoustic directivity, and bow shock. The impulsive noise guideline thresholds are also labeled and color gradients illustrate the gradual decay of noise level. Notice that the noise levels are higher in front of the weapon than they are behind. Additionally, since there is no wind present, the noise contour is symmetrical on either side of the direction of fire.

Case 2: 105-mm Stryker, High Explosive (HE) Round, No Wind, Midday, Clear Skies

This case (Figure 4) illustrates firing area noise, acoustic directivity, bow shock, and target area noise. The impulsive noise guideline thresholds are also labeled and color gradients illustrate the gradual decay of noise level. Notice that the noise levels are higher in front of the weapon than they are behind. Target area noise enlarges the noise contour about the target point. Additionally, since there is no wind present, the noise contour is symmetrical on either side of the direction of fire.

Case 3: 1# Trinitrotoluene (TNT), No Wind, Midday, Clear Skies

This case (Figure 5) contains only target area noise (the point of detonation). An unconfined charge radiates sound in all directions equally. The impulsive noise guideline thresholds are also labeled and color gradients illustrate the gradual decay of noise level. Since there is no wind present in this case, the noise contour is circular.

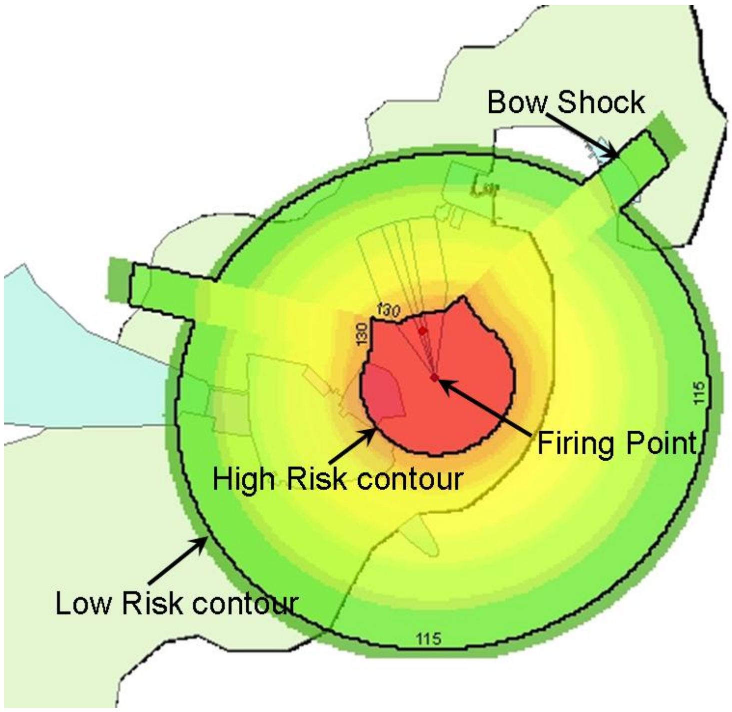

Figure 3. Sample output from RMTK Noise Tool (Case #1); parameters are 105-mm Stryker, Training Round (inert), no wind, midday, clear skies.

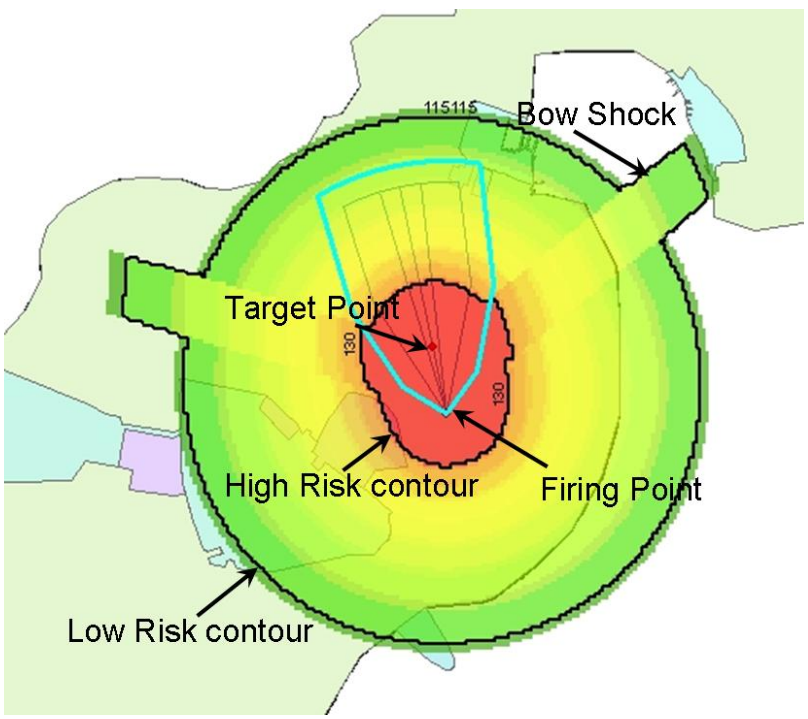

Figure 4. Sample output from RMTK Noise Tool (Case #2); parameters are 105-mm Stryker, HE round, no wind, midday, clear skies.

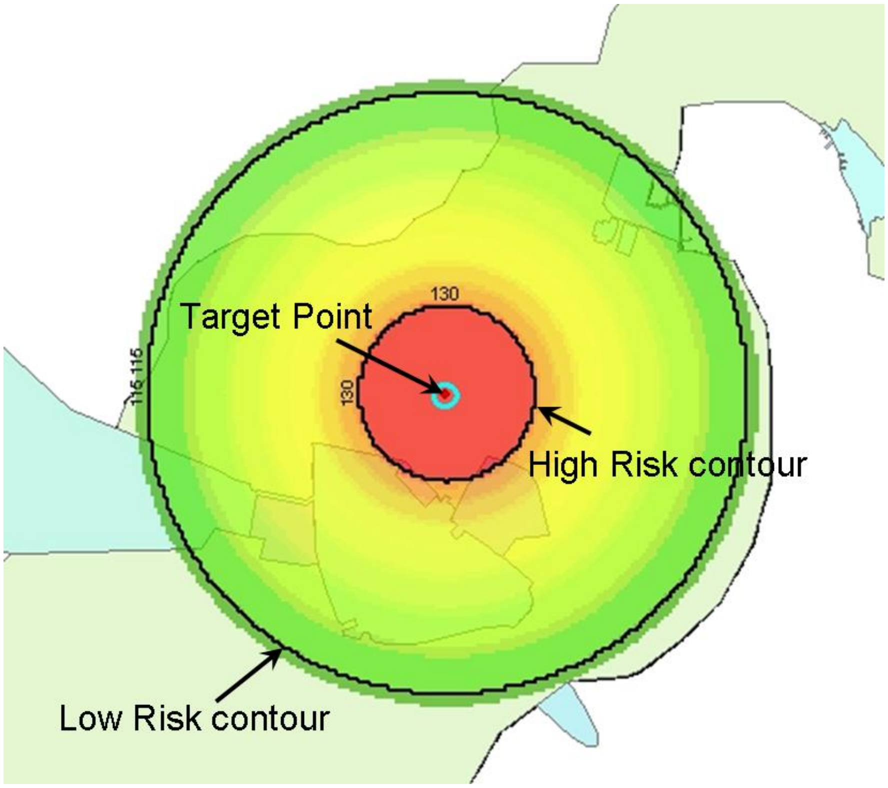

Figure 5. Sample output from RMTK Noise Tool (Case #3); parameters are 1# TNT, no wind midday, clear skies.

Case 4: 1# TNT, 5 mph Wind Out of the Southwest, Summer, Midday, Clear Skies

This case (Figure 6) contains only target area noise (the point of detonation). An unconfined charge radiates sound in all directions equally. The impulsive noise guideline thresholds are also labeled and color gradients illustrate the gradual decay of noise level. However, since there is wind present, the noise contour is shifted. Notice that the contour appears to be smeared towards the northeast as a result of wind coming out of the southwest.

Case 5: 105-mm Stryker, HE Round, 5 mph Wind Out of the Southwest, Summer, Midday, Clear Skies

This case (Figure 7) shows firing area noise, acoustic directivity, bow shock, and target area noise. The impulsive noise guideline thresholds are also labeled and color gradients illustrate the gradual decay of noise level. Notice that the noise levels are higher in front of the weapon than they are behind. Target area noise enlarges the noise contour about the target point. However, since there is wind present, the noise contour is shifted. Notice that the contour appears to be smeared towards the northeast as a result of wind coming out of the southwest.

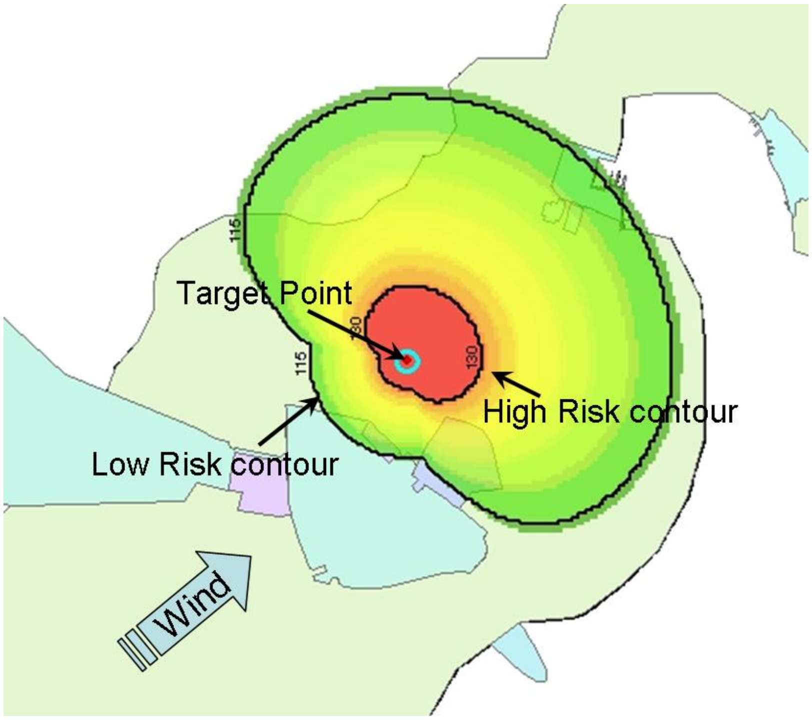

Figure 6. Sample output from RMTK Noise Tool (Case #4); parameters are 1# TNT, 5 mph wind out of the southwest, summer, midday, clear skies.

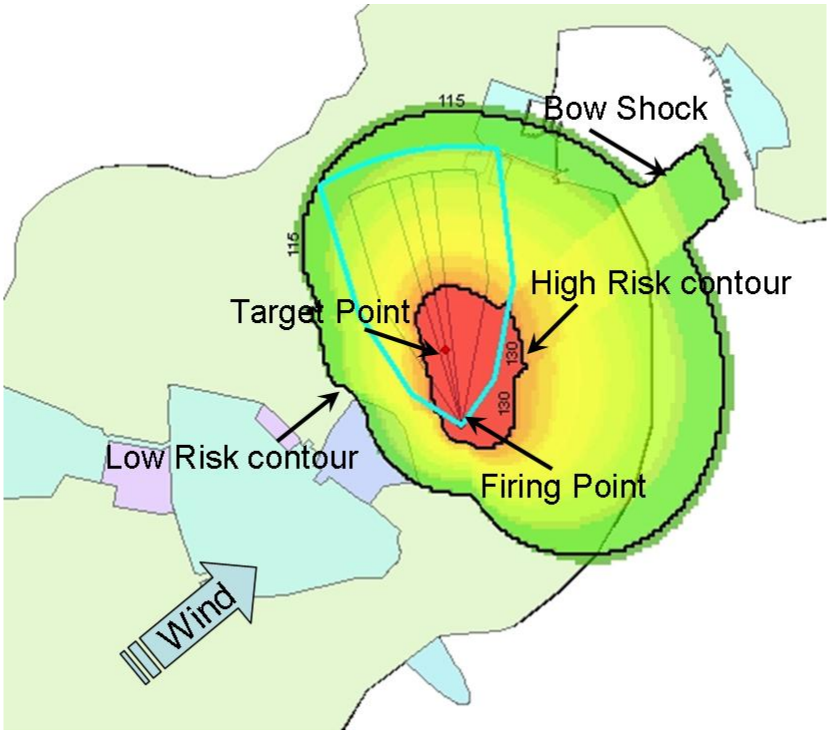

Figure 7. Sample output from RMTK Noise Tool (Case #5); parameters are 105-mm Stryker, HE round, 5 mph wind out of the southwest, summer, midday, clear skies.

RMTK Noise CALFEX Generation

Starting a CALFEX Generation

Under the “SDZ Manager” pull-down, select “RMTK Noise,” then “View/Delete RMTK Noise Grids.”

View/Delete RMTK Noise Grids Form

Select the “View or Merge Selected Grids” radial button. Check the box in front of “Merge Grids Together (CALFEX)” (Figure 8) and then use the checkboxes to select the desired noise grids. Enter a name for the CALFEX, and click “OK.”

CALFEX noise grids are calculated by picking the largest noise value at each grid point. When a CALFEX is successfully generated, the component grid layers are also displayed. Contributions of each noise grid may be assessed by turning the grids of interest on and off.

RMTK Noise Delete Grids Function

Starting the Delete Grids Function

Under the “SDZ Manager” pull-down, select “RMTK Noise,” then “View/Delete RMTK Noise Grids.”

View/Delete RMTK Noise Grids Form

Select the “Delete Selected Grids and Contours” radial button (Figure 9). If you want to delete all, check the “Delete entire workspace (not CALFEX)” checkbox. If you only want to delete specific noise grids, select those grids in the list. Click “OK” when you have selected grids to delete.

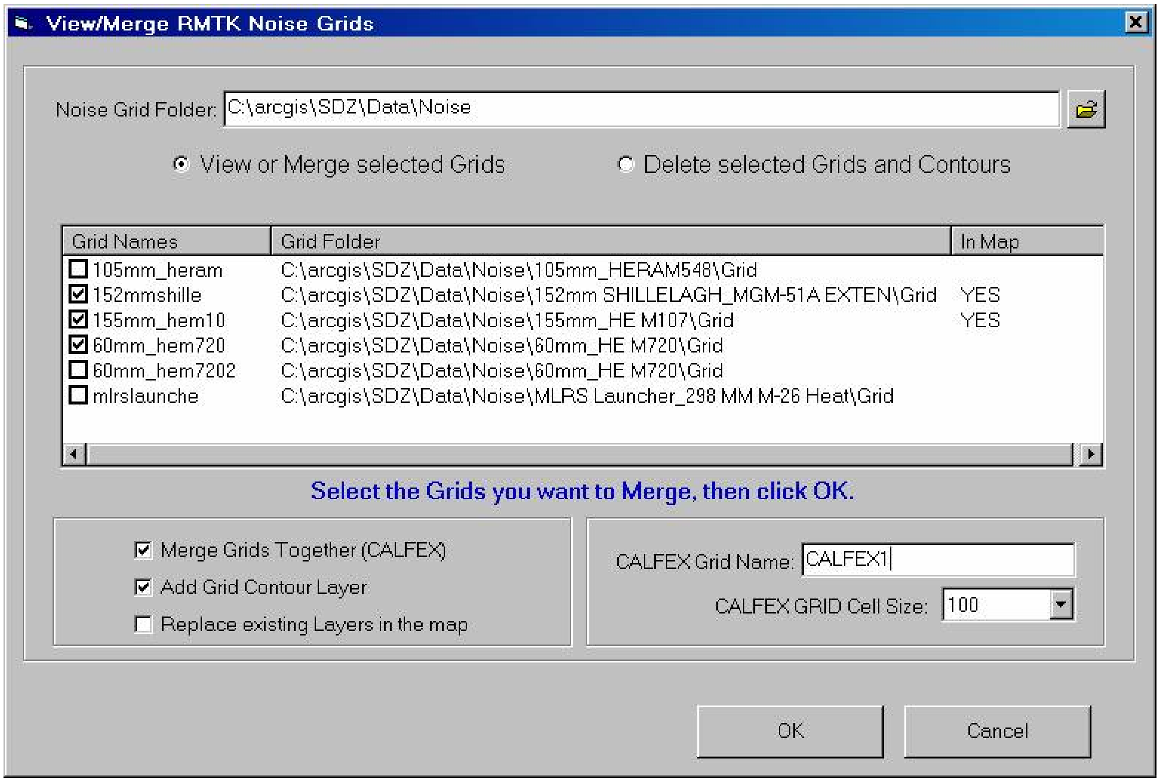

Figure 8. CALFEX generation screen in RMTK Noise Tool.

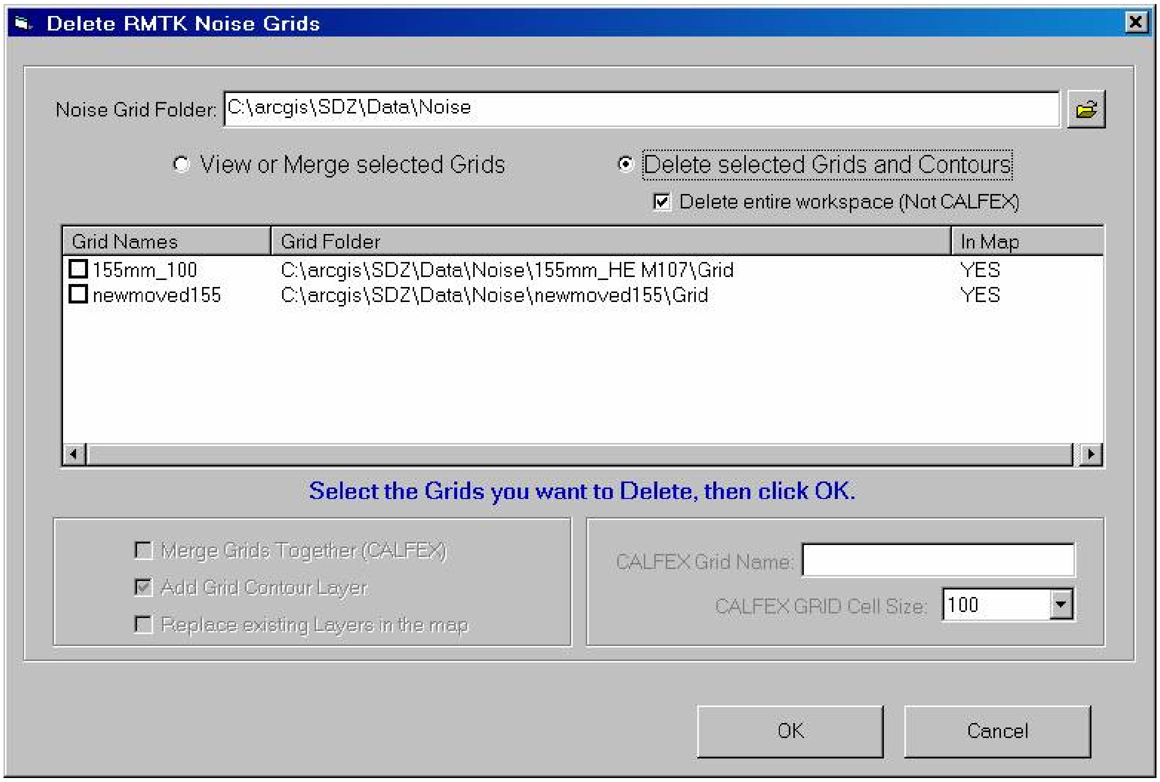

Figure 9. Delete Noise Grid screen in the RMTK Noise Tool.

3 Software Requirements

The *RMTK Noise Tool* conforms to a list of specified requirements. The complete list was specified Appendix A5 of the *RMTK FDD* (RMTK "Functional Description Document"), which are listed in the Appendix to this report. Because this first version of the *RMTK Noise Tool* conforms to a subset of the original expanded set of requirements, as agreed upon by the RMTK User Working Group (RMTK UWG). Table 1 lists the shortened set of requirements, and the following section discusses each requirement in detail.

Table 1. *RMTK Noise Tool* version 1 requirements.

No.	Requirement
A5.a	The *RMTK Noise Tool* will assist the user in predicting training noise, generated from weapons and demolitions. RMTK will assist the user in predicting potential noise, synchronizing training requirements, and identifying mitigation and education requirements for the public concerning training noise.
A5.b	The *RMTK Noise Tool* will determine and display noise levels for specific weapon and vehicle systems on a range or training area in conjunction with a range of meteorological conditions on a case by case basis.
A5.c	The *RMTK Noise Tool* will provide the user the ability to forecast noise contours from scheduled facilities and allow the user to perform "what-if" scenarios, to include weather, when to shoot or mitigate
A5.d	The *RMTK Noise Tool* will provide the capability to assess noise due to CALFEX.
A5.1.a	The *RMTK Noise Tool* will allow the user to choose season, time of day, cloud cover, wind speed, wind direction, and terrain type. Weather options include a "worst case" condition.
A5.2.a	The *RMTK Noise Tool* will provide output which will be +/- 10 percent of BNOISE2™ and SARNAM™, given identical input and metric.
A5.2.b	The *RMTK Noise Tool* will display noise modeling output using a default standard color gradient, with break points at specific threshold values, but will allow the user to adjust threshold values. Default thresholds are weapons system class specific (examples: small arms, blast noise, or high performance).
A5.2.c	The *RMTK Noise Tool* will have a graduated color bar with green indicating low risk and red indicating high risk. The colors will be anchored initially at 115 dB and 130 dB for large arms.

Requirement A5.a

This requirement is partially met. Not all inventory weapons systems are currently supported. The *RMTK Noise Tool* performs noise assessments for the following weapon systems:

- tanks and bradleys
- artillery
- mortars

- **T**ube-launched, **O**ptically-tracked, **W**ire command-link guided missile system (TOW)
- multiple launch rocket system (MLRS)
- limited demolitions
- limited mines
- limited charges
- limited rockets.

Requirement A5.b

This requirement is met. The options for choosing meteorological conditions are:

- season (winter, spring, summer, autumn)
- time of day (dawn, midday, dusk, night, worst case)
- cloud cover (clear, partly cloudy, cloudy, worst case)
- wind speed (0 mph, 5 mph, 10 mph, 15 mph, 20 mph, worst case)
- wind direction (N, NNE, NE, etc., worst case).

Requirement A5.c

Because of the flexibility in choosing meteorological conditions and the speed of the calculations, Range Officers can forecast noise contours and perform “what-if” scenarios with ease.

Requirement A5.d

The *RMTK Noise Tool* has the ability to perform a CALFEX, although it will not include small arms at this time. The CALFEX is calculated by using the noise CALFEX tool to select the desired noise contours and then by combining them such that the maximum value at each point on the grid is chosen. This provides the maximum extent of noise for a CALFEX.

Requirement A5.1.a

The “worst case” categories are selected such that the strongest propagation conditions exist. The defaults for the Worst Case category are:

- season = winter
- time of day = night
- cloud cover = cloudy
- wind speed = 20 mph
- wind direction = each azimuth is treated as the downwind direction.

Requirement A5.2.a

The *RMTK Noise Tool* has been thoroughly tested to ensure that output noise levels are within +/- 10 percent of BNOISE2™ for large arms. Small arms testing has not yet been conducted, as small arms are not yet included in the *RMTK Noise Tool*.

Requirement A5.2.b, c

PK15(met) levels are displayed using color gradients. According to the Impulsive Noise Guidelines, when the level is 115 dB unweighted peak or less, there is a very low risk of receiving a noise complaint. When the level rises above 130 dB unweighted peak, there is a very high risk of receiving a noise complaint. To visually convey this information, levels greater than or equal to 130 dB are colored red (for large arms), levels on the order of 115 dB are colored green, and levels in-between are shown as graduated colors from red through amber into green. The gradual changes in color clearly show the user that sound decays gradually, not abruptly. Levels associated with colors are alterable in the GIS interface.

4 Database and Calculation Engine

The *RMTK Noise Tool* uses a unique database to store necessary information for noise calculations and also a unique calculation engine. These items are described in the next two sections in more detail.

RMTK Noise Tool Database

There are actually two databases associated with the *RMTK Noise Tool*. The first (referred to here as the "noise database") is only associated with the Noise Tool and contains all of the necessary information for calculating the noise contours. The second (referred to here as the "translation table") is a translation table within the overall RMTK database framework.

The noise database for the *RMTK Noise Tool* is a standalone database contained in the file `ns.txt`. This file contains information on equivalent yields of explosives, C-weighted Sound Exposure Level (CSEL) acoustic efficiencies, CSEL acoustic directivities, weapon and ammunition specific information, and translations from Department of Defense identification code (DODIC) numbers (munitions) and National Supply Number (NSN) (weapons) to Annoise tags. The database is an expansion of the original BNOISE2™ database, just as the Annoise calculation engine is a version of the BNOISE2™ calculation engine.

Significant updates to the munitions data have been made according to Army Technical Manual (TM) 43-0001-28, -29, -30, -37, -38, and -39 and are referenced specifically in the database. This includes corrections to munition dimensions, included charge type and weight, initial velocity, and dimensions. Corrections to the TOW series parameters were made according to Schomer and Raspet (1984). Corrections to the Mine Clearing Line Charge (MICLIC) parameters, including directivity corrections, were made according to Environmental Noise Study No. 52-34-5271-97 (USACHPPM 1998). Additional major adjustments to the database were the addition of DODIC numbers and NSN numbers and their translations into existing noise codes. DODIC numbers were obtained to match the RMTK SDZ database of available munitions. The NSNs were obtained via a combination of Army Training Manuals and personal communications. References to specific manuals are associated with the data entries.

The translation table exists as part of the RMTK SDZ database. It acts as a translator between the SDZ tool weapon source code and the National Stock Number (NSN) used by the Noise Tool.

Annoise

Annoise is the name of the calculation engine in the *RMTK Noise Tool*. Annoise is derived directly from the BNOISE2™ calculation engine. A complete description of the BNOISE2™ calculation engine is available in White (2000; 1999). The primary differences between Annoise and BNOISE2™ are that the Annoise engine is optimized for calculating peak levels; it exists as a *.dll file instead of an executable (*.exe) file; and it accepts a set of inputs unique to the *RMTK Noise Tool*.

5 Noise Complaint Criteria

The Army has developed a set of criteria, based on experience and on data gathered over many years, for the risk of receiving noise complaints due to blast noise from training and testing (Pater 1976; Luz et al. 1983; Luz and Eastridge 2001). These criteria state that as long as the noise level in the community is below a specified threshold level, the likelihood that the noise will evoke complaints is small. (This risk is never zero.) The likelihood of receiving noise complaints increases as noise levels become louder, until a second threshold level is reached at which noise complaints are very likely. For large weapons such as artillery and tanks, the complaint threshold levels are known with good reliability. A blast noise event which exposes the community to an unweighted peak sound pressure level less than 115 dB is unlikely to evoke noise complaints. On the other hand, community exposure to an unweighted peak sound pressure level of 130 dB is very likely to result in noise complaints.

Enough is known about weapons as noise sources, and about the statistics of how weather affects sound attenuation to make a reliable prediction of the sound levels and the statistical variation at a given location. Because of the variability of propagation conditions due to weather, the statistical variation in received sound level from the same noise sources is typically large. It is possible to provide a statistical guideline, much like a weather report of "35 percent chance of rain." This application provides an "85 percent solution," that is, it will predict, for a given weapon and given geographical area, a distance at which the actual noise level will be less than the predicted level approximately 85 percent of the time. Of course, this means that approximately 15 percent of the time, the actual level will exceed the predicted level. Training during "worst case" conditions (e.g., low cloud ceiling, dawn, dusk, and nighttime) will lead to increased risk of complaints.

The *RMTK Noise Tool* outputs a map indicating complaint risk by colors and also by decibel values. This is done to simplify interpretation. For example, red denotes a high risk of complaint, while green denotes a low risk. The colors are graded between these regions as a way of clearly showing that the transition from low risk to high risk is not an abrupt change, but one that gradually increases.

Community response to continuous noise sources, such as traffic, aircraft, and trains, has been studied extensively. For continuous noises in the community, the setting is important: acceptable noise levels in areas having a park, school, or hospital are different from those in residential areas. Time of day is also important. For continuous noise sources, a penalty is assessed for noises made during evening and nighttime. Community response to impulsive noises has not yet been well-studied. Because the *RMTK Noise Tool* is the first widespread implementation of a noise management tool for impulsive noise, it will be important to acquire feedback on the noise criteria as it relates to community setting, time of day, and other factors. Ways of implementing feedback in conjunction with a complaint management program are now being explored.

6 Weather Cases

Weather cases for the *RMTK Noise Tool* are based on average profiles and seasonal averages (Salomons et al. 1994). Sound speed profiles were calculated according to the methodology described in the paper. Cases not described in the article were removed from the set, and the remaining profiles were comparatively matched to the 27 averaged profiles described in the paper. This chapter presents the equations and parameters used, figures of the comparisons, and then tables describing the matches of averaged profile cases to time of year and of day.

Calculations

Calculation of the sound speed profiles begins with calculating the Obukhov length L as a function of Pasquill classification:

$$\frac{1}{L} = B_1 \log_{10}(z_0) + B_2 \qquad \textbf{Eq 1}$$

where:

$z_0 \leq 0.5\text{m}$ = the roughness length of the ground

B_1 and B_2 are described in Table 2.

Next the profiles for wind speed $u(z)$ and potential temperature $\theta(z)$ are calculated using the empirical Businger-Dyer profiles:

$$u(z) = \frac{u_*}{\kappa}\left[\ln(\frac{z}{z_0}+1) - \Psi_M(\frac{z}{L})\right] \qquad \textbf{Eq 2}$$

and

$$\theta(z) - \theta_0 = \frac{\theta_*}{\kappa}\left[\ln(\frac{z}{z_0}+1) - \Psi_H(\frac{z}{L})\right] \qquad \textbf{Eq 3}$$

where:

u_*, θ_*, θ_0, z_0, and L are parameters

κ is the Von Karman constant with a value of $\kappa = 0.41$

The functions Ψ_M and Ψ_H are defined below.

For an unstable atmosphere ($z/L<0$), use:

$$\Psi_M(\frac{z}{L}) = 2\ln(\frac{1+x}{2}) + \ln(\frac{1+x^2}{2}) - 2\arctan(x) + \frac{\pi}{2} \qquad \textbf{Eq 4}$$

$$\Psi_H(\frac{z}{L}) = 2\ln(\frac{1+x^2}{2}) \qquad \textbf{Eq 5}$$

with $x = (1-16z/L)^{1/4}$

For a stable atmosphere ($z/L>0$), use:

$$\Psi_M(\frac{z}{L}) = \Psi_H(\frac{z}{L}) = \begin{cases} -5\frac{z}{L} & \text{for } z \le 0.5L \\ -7\ln(\frac{z}{L}) - \frac{4.25}{(z/L)} + \frac{0.5}{(z/L)^2} - 0.852 & \text{for } z > 0.5L \end{cases} \qquad \textbf{Eq 6}$$

Once Ψ_M and Ψ_H are determined, one can calculate u_* based on the wind speed at 10 m height (u_{10}). The value for θ_* can then be calculated from the following definition of the Obukhov length L.

$$L = \frac{\theta_0 u_*^2}{\kappa g \theta_*} \qquad \textbf{Eq 7}$$

where:

θ_0 is the potential temperature at the ground
g is the gravitational acceleration.

Now it is necessary to transform the potential temperature into the absolute temperature, using the following equation (which assumes dry air):

$$T(z) = \theta(z) - 0.01z \qquad \textbf{Eq 8}$$

Finally, the sound speed profile can be calculated with:

$$c(z) = 20.064\sqrt{T(z)} + u(z)\cos(\phi - \beta) \qquad \textbf{Eq 9}$$

where:

ϕ is the wind direction
β is the direction of sound propagation.

Comparisons

The number of calculated profiles was reduced according the data tables in Salomons et al. (1994). This was done by looking only at N=0, 4, and 8, which correspond to cloud covers of 0 percent, 50 percent, and 100 percent, respectively, and then only keeping pairs of Pasquill class and wind speed that appeared in the tables. (Table 2 lists Values for Pasquill Class constants.) This eliminated many of the more severe sound speed profiles. Figures 10 to 15 show the comparisons. The dashed lines in the figures represent the best match averaged case(s).

Table 2. Values for Pasquill Class constants.

Pasquill Class	A	B	C	D	E	F
B_1	0.04	0.03	0.02	0	-0.02	-0.05
B_2	-0.08	-0.035	0	0	0	0.025

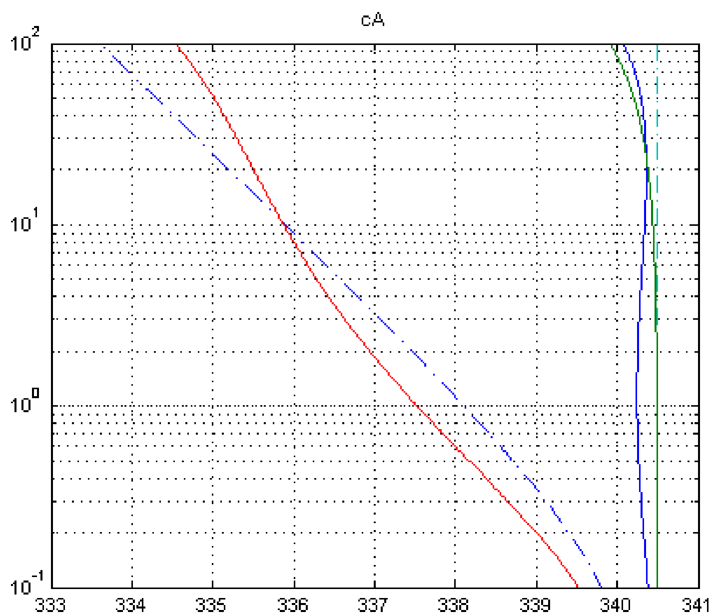

Figure 10. Comparisons of averaged sound speed profiles to Pasquill Class A generated sound speed profiles.

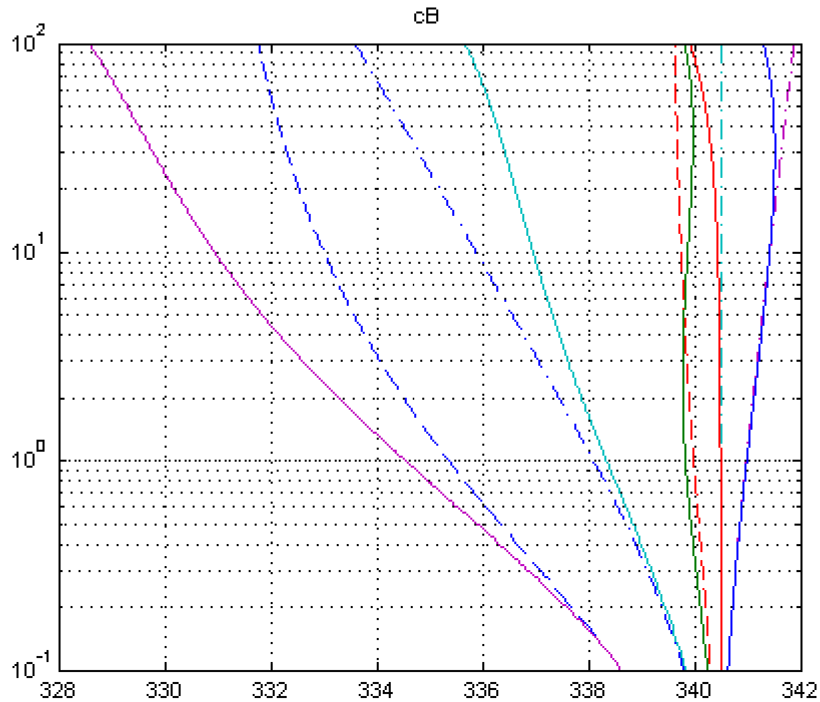

Figure 11. Comparisons of averaged sound speed profiles to Pasquill Class B generated sound speed profiles.

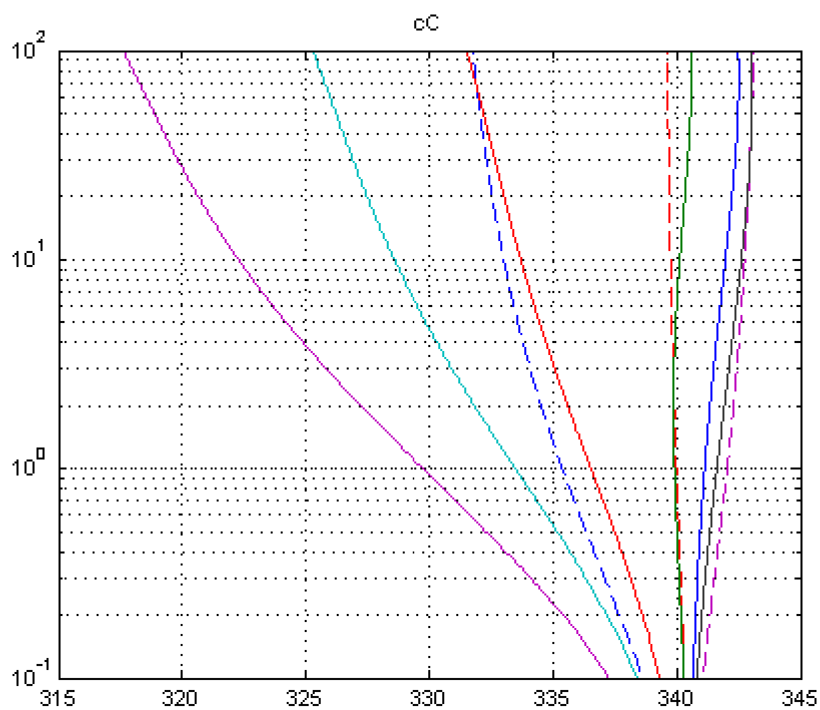

Figure 12. Comparisons of averaged sound speed profiles to Pasquill Class C generated sound speed profiles.

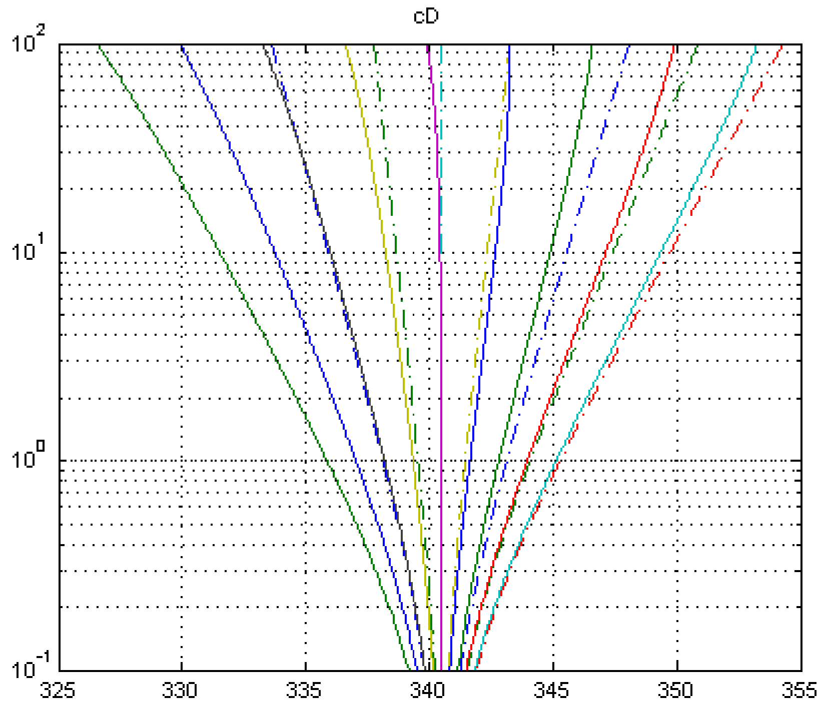

Figure 13. Comparisons of averaged sound speed profiles to Pasquill Class D generated sound speed profiles.

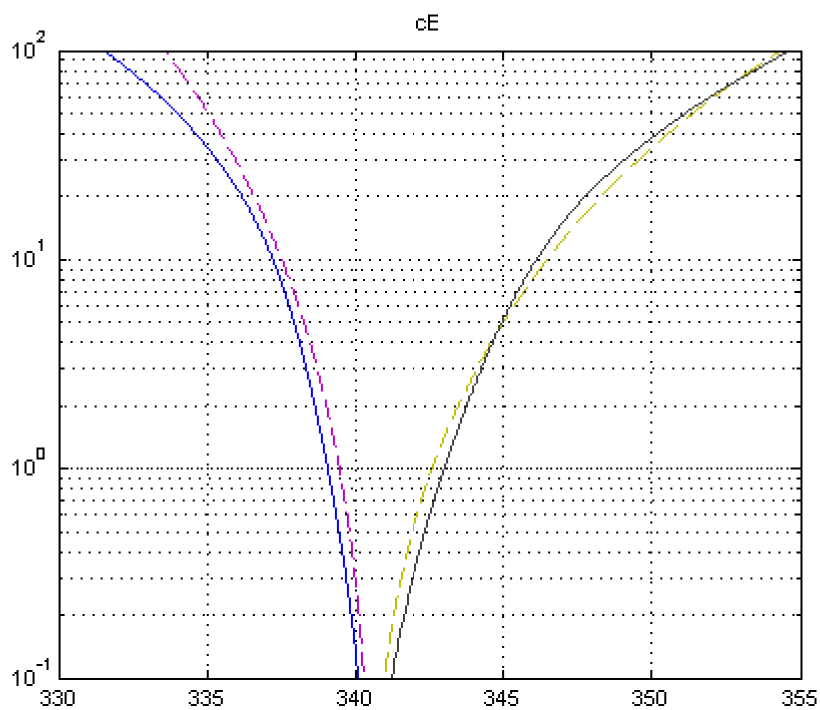

Figure 14. Comparisons of averaged sound speed profiles to Pasquill Class E generated sound speed profiles.

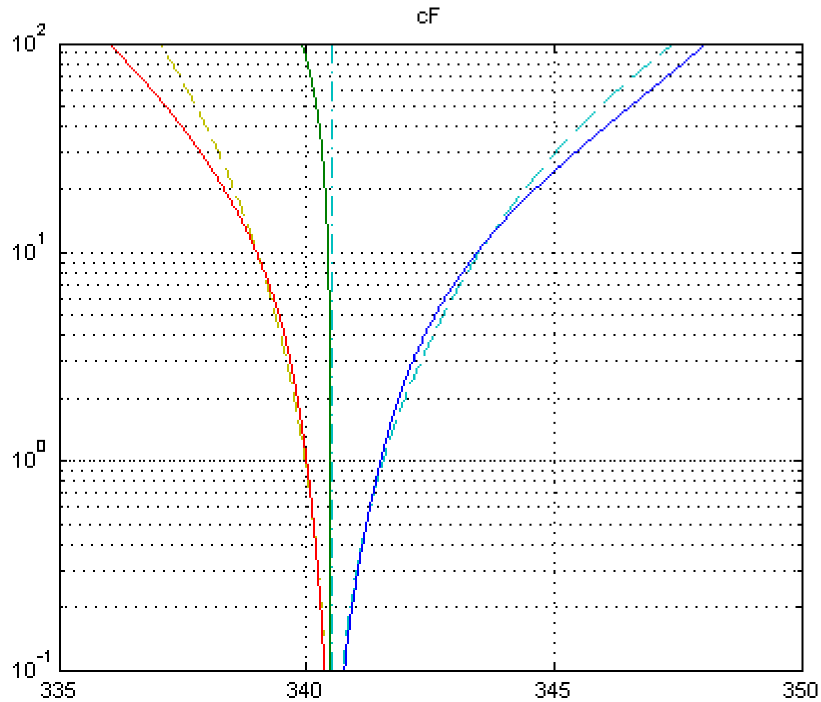

Figure 15. Comparisons of averaged sound speed profiles to Pasquill Class F generated sound speed profiles.

Tables 3 through 18 show how the sound speed profiles are matched to specific weather conditions. The tables are organized into three sets. The first set (Tables 3 through 8) contains a mapping of the sound speed profiles to Pasquill class and wind speed. The second set (Tables 9 through 13) contains a subset of the relevant tables in Salomons et al. (1994). The third set (Tables 14 through 18) mirrors the second set, but contains the translation into sound speed profile number for upwind and downwind cases.

Table 3. Pasquill Class A reference profile numbers.

mph	Reference Profile Number
0	C11
5 downwind	C11
5 upwind	C08

Table 4. Pasquill Class B reference profile numbers.

mph	Reference Profile Number
0	C11
5 downwind	C12
5 upwind	C08
10 downwind	C03
10 upwind	C01

Table 5. Pasquill Class C reference profile numbers.

Mph	Reference Profile Number
10 downwind	C05
10 upwind	C01
15 downwind	C01
15 upwind	C01
20 downwind	C03
20 downwind	C01

Table 6. Pasquill Class D reference profile numbers.

Mph	Reference Profile Number
0	C11
5 downwind	C13
5 upwind	C09
10 downwind	C15
10 upwind	C08
15 downwind	C16
15 upwind	C08
20 downwind	C17
20 upwind	C08

Table 7. Pasquill Class E reference profile numbers.

Mph	Reference Profile Number
10 downwind	C27
10 upwind	C19

Table 8. Pasquill Class F reference profile numbers.

mph	Reference Profile Number
0	C11
5 downwind	C25
5 upwind	C20

Table 9. Winter day Pasquill classes.

Clouds/mph	0	5	10	15	20
0%	A	B	B	C	D
50%	B	B	C	D	D
100%	D	D	D	D	D

Table 10. Spring day Pasquill classes.

Clouds/mph	0	5	10	15	20
0%	A	A	B	C	C
50%	B	B	C	C	D
100%	D	D	D	D	D

Table 11. Summer day Pasquill classes.

Clouds/mph	0	5	10	15	20
0%	A	A	B	C	C
50%	A	B	B	C	D
100%	D	D	D	D	D

Table 12. Autumn day Pasquill classes.

Clouds/mph	0	5	10	15	20
0%	A	B	B	C	D
50%	B	B	C	D	D
100%	D	D	D	D	D

Table 13. Nighttime Pasquill classes.

Clouds/mph	0	5	10	15	20
0%	F	F	E	D	D
50%	F	F	D	D	D
100%	D	D	D	D	D

Table 14. Winter day reference profile numbers; downwind/upwind.

Clouds/mph	0	5	10	15	20
0%	C11/C11	C12/C08	C03/C01	C01/C01	C17/C08
50%	C11/C11	C12/C08	C05/C01	C16/C08	C17/C08
100%	C11/C11	C13/C09	C15/C08	C16/C08	C17/C08

Table 15. Spring day reference profile numbers; downwind/upwind.

Clouds/mph	0	5	10	15	20
0%	C11/C11	C11/C08	C03/C01	C01/C01	C03/C01
50%	C11/C11	C12/C08	C05/C01	C01/C01	C17/C08
100%	C11/C11	C13/C09	C15/C08	C16/C08	C17/C08

Table 16. Summer day reference profile numbers; downwind/upwind.

Clouds/mph	0	5	10	15	20
0%	C11/C11	C11/C08	C03/C01	C01/C01	C03/C01
50%	C11/C11	C12/C08	C03/C01	C01/C01	C17/C08
100%	C11/C11	C13/C09	C15/C08	C16/C08	C17/C08

Table 17. Autumn day reference profile numbers; downwind/upwind.

Clouds/mph	0	5	10	15	20
0%	C11/C11	C12/C08	C03/C01	C01/C01	C17/C08
50%	C11/C11	C12/C08	C01/C01	C16/C08	C17/C08
100%	C11/C11	C13/C09	C15/C08	C16/C08	C17/C08

Table 18. Nighttime reference profile numbers; downwind/upwind

Clouds/mph	0	5	10	15	20
0%	C11/C11	C25/C20	C27/C19	C16/C08	C17/C08
50%	C11/C11	C25/C20	C15/C08	C16/C08	C17/C08
100%	C11/C11	C13/C09	C15/C08	C16/C08	C17/C08

Calibration

The *RMTK Noise Tool* uses theoretical propagation conditions to calculate acoustic propagation during different weather conditions. These propagation conditions, or weather cases described in the previous section were used to calculate the transfer functions used in the *RMTK Noise Tool* to propagate noise over distance. Since the Fast Field Program (FFP) calculation used to generate these transfer functions is theoretical, the resulting transfer functions needed to be calibrated to real defensible values. To accomplish this, the decision was made to adjust the free-field propagation transfer function values for PK15 (Event) to the American National Standards Institute (ANSI) S2.20 (ANSI S2.20-1983) curve for unweighted peak pressure. This decision was made based on data shown in Ford et al (1993, Figure 4 [not reproduced here]). In this figure, free-field peak pressure levels measured from small charge detonations are plotted against the ANSI S2.20 curve. The data points all fall quite close to the theoretical ANSI curve. Because the values plotted in this figure are actual values, not simply averages, the decision was made to calibrate PK15 (Event) to ANSI S2.20 instead of the PK50 (event) levels.

The calibration was accomplished by calculating the ANSI S2.20 predicted peak levels for 1 kg of TNT and then comparing those numbers to Annoise-generated values for the same charge type and weight and at several distances (200, 400, 600, 800, 1000, and 2000 m). Adjustments were then made to the free-field transfer function so that the levels matched ANSI S2.20. Since the specific weather case transfer functions act as a propagation condition-specific adjustment to the free-field transfer function, this effectively calibrated all of the weather cases. Values for ANSI S2.20, the before and after values of the free-field simulation, and the adjustment (in dB) that each distance required are listed in Table 19.

Table 19. Calibration information.

Case	Metric	200 m	400 m	600 m	800 m	1 km	2 km
ANSI S2.20	Peak	144 dB	137 dB	133.2dB	130.4dB	128.3dB	121.7dB
Free-Field Pre-calibration	PK15	147.5dB	141 dB	137.5dB	135 dB	132.5dB	126 dB
Free-Field Post-calibration	PK15	144 dB	137 dB	133 dB	130 dB	128.5dB	122 dB
Adjustment	PK15	-3.5 dB	-4 dB	-4.5 dB	-5 dB	-4 dB	-4 dB

7 Time on Target Assessment

"Time on Target" is an exercise that involves multiple weapons firing into a target area (e.g., 100 m x 100 m), all detonating within a specific time frame of no more than ± 3 s. Researchers were asked to include a noise assessment of this type of exercise in the *RMTK Noise Tool.* Because the Noise Tool performs all assessments in terms of peak level, it was hypothesized that an addition of peak sound pressure levels was highly unlikely. A probability-based analysis was performed to test this hypothesis. The following sections synopsizes the results and give more specific description of the analysis and the results of that analysis.

Summary

A large weapon blast has a duration of about 100 ms. The positive sound pressure portion has a much shorter duration, roughly 10 ms at 1 km. For the pressures to add constructively, there must be an overlap in positive pressures. Because the area and time frame are relatively large in a time on target exercise compared to the positive phase duration of the sound waves, it is extremely unlikely that the sound waves from different detonations will interfere constructively at the receiver location.

An analysis determining the probability that the acoustic signal from two or more detonations will arrive at a receiver location within a 10 ms "time window" has been performed and partially disproved the hypothesis that the peak sound pressure levels would be highly unlikely to interfere constructively. In fact, once the 85 percent solution criteria were applied to the results, it was found that, for 11 or more weapons firing, some addition of peak level would take place. If the allowable time window is 7.5 ms, then the criteria are only met for 12 or more weapons. If the allowable time window is 5 ms, the criteria are met for 14 or more weapons. If the time window is made narrower, to indicate more than ½ positive pressure overlap, the criteria of occurring 15 percent of the time or more is not met for fewer than 18 weapons firing. There is a less than 1 percent chance that three or more detonations will add constructively at a receiver location for 18 or fewer weapons firing.

However, the subject matter expert (SME) for artillery training stated that, for more than 10 weapons firing, human error decreases the likelihood of attaining the stringent requirements necessary for increasing peak levels. When

combined with the atmospheric effects, which were not taken into account for this statistical analysis and which introduce variations in path length, the actual likelihood of an effective increase in peak level may be neglected. Therefore, in RMTK Noise, there is no adjustment to peak levels for a time on target exercise.

Although the peak levels change minimally, the event sound exposure level (SEL) could change dramatically. During a time on target, some level close to the peak level is sustained for a longer duration at the receiver location due to temporally clustered explosions, potentially causing the perception of a louder sound, and also more vibrations.

Again, the *RMTK Noise Tool* is only assessing in terms of peak levels. Data to reliably predict reactions to a time on target, which would possibly need to be based on an event SEL instead of a simple peak level, is not available.

Analysis Details

Because the receiver distances are large compared to the target area width, only the separation in x contributes to the time delay. The time separation between any two detonations can be found from the following relation:

$$\Delta T = T_2 - T_1 = \frac{\Delta x}{c} + \Delta t \qquad \textbf{Eq 9}$$

where:

ΔT	=	the time separation in seconds at the receiver
$T_2 - T_1$	=	the time difference of arrival at the receiver location [s]
Δx	=	the spatial separation between the two detonations [m]
c = 340 m/s	=	the speed of sound
Δt	=	the time separation of detonations.

If it is stated that $|\Delta T| \leq 10\,\text{ms}$ for any overlap to occur, and defined that minimal overlap occurs for $|\tau_0| = 10\,\text{ms}$, then:

- 10% overlap occurs for $|\tau_{10}| = 9\,\text{ms}$
- 25% overlap occurs for $|\tau_{25}| = 7.5\,\text{ms}$
- 50% overlap occurs for $|\tau_{50}| = 5\,\text{ms}$
- 75% overlap occurs for $|\tau_{75}| = 2.5\,\text{ms}$

Now the problem can be treated in the following way:

> Let w represent the largest horizontal dimension of the target area and let $\delta = 6\text{s}$ represent the largest time separation of detonations. The ranges for Δx and Δt are now $[-w/2 \le \Delta x \le w/2]$ and $[-3\text{s} \le \Delta t \le 3\text{s}]$, because:

$$\max(\frac{\Delta x \,|_{-w/2}^{w/2}}{c}) = \frac{w}{c} \qquad \textbf{Eq 10}$$

and

$$\max(\Delta t) = \delta \qquad \textbf{Eq 11}$$

and assuming that $\delta >> w/c$, the largest time separation at the receiver is:

$$-(\frac{w}{c} + \delta) \le \Delta T \le (\frac{w}{c} + \delta) \qquad \textbf{Eq 12}$$

Assume that Δt is uniformly distributed. Because $\delta >> w/c$ for the example, w/c can be neglected compared to δ. Consequently, ΔT is uniformly distributed. This means that, to find the probability that two detonations will occur within the allowable time limit, one can use the relation:

$$P_{t,m}(|\Delta T| \le \tau_m) = \frac{2\tau_m}{\delta} \qquad \textbf{Eq 13}$$

The probability is statistically distributed because Δx and Δt are both uniformly distributed. For one pair of detonations, this gives $P_{t,0} = 0.0033$. To find the probability that any given pair will be additive, one must use the relation $P_n = qP_{t,m}^{r-1}$. To find the number of pairs (or triples or quadruples, etc.) the relation of:

$$q = \frac{n!}{r!(n-r)!} \qquad \textbf{Eq 14}$$

where:

$n =$ # weapons firing
$r =$ # in a group.

For example, if 18 weapons fire, and the analysis is interested in pairs, then the result is:

$$\frac{18!}{2!(18-2)!} = 153 \text{ pairs} \qquad \textbf{Eq 15}$$

This same analysis is performed for pairs, triples, and quadruples. The following tables list the results. In addition to the slight overlap case ($\tau = 10\,\text{ms}$, Table 20), cases were run for 10 percent (Table 21), 25 percent (Table 22), 50 percent (Table 23), 75 percent (Table 24), and 90 percent (Table 25) overlap. To obtain the percent time that the overlap occurs, simply multiply the probabilities in the tables by 100.

Table 20. Barely overlapping; tau=0.010 s.

n/r	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.02	0.0333	0.05	0.07	0.0934	0.1201	0.1501	0.1834	0.2201	0.2601	0.3035	0.3502	0.4002	0.4536	0.5103
3	0	0.0001	0.0002	0.0004	0.0006	0.0009	0.0013	0.0018	0.0024	0.0032	0.004	0.0051	0.0062	0.0076	0.0091
4	0	0	0	0	0	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001

Table 21. Overlapping 10%; tau=0.009 s.

n/r	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.018	0.03	0.045	0.063	0.084	0.1081	0.1351	0.1651	0.1981	0.2341	0.2732	0.3152	0.3602	0.4082	0.4593
3	0	0.0001	0.0002	0.0003	0.0005	0.0008	0.0011	0.0015	0.002	0.0026	0.003	0.0041	0.005	0.0061	0.0074
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0001	0.0001

Table 22. Overlapping 25%; tau=0.0075 s.

n/r	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.015	0.025	0.0375	0.0525	0.07	0.0901	0.1126	0.1376	0.1651	0.1951	0.2277	0.2627	0.3002	0.3402	0.3828
3	0	0.0001	0.0001	0.0002	0.0004	0.0005	0.0008	0.001	0.0014	0.0018	0.0023	0.0028	0.0035	0.0043	0.0051
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 23. Overlapping 50%; tau=0.005 s.

n/r	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.01	0.0167	0.025	0.035	0.0467	0.0601	0.0751	0.0981	0.1101	0.1301	0.1518	0.1752	0.2002	0.2269	0.2553
3	0	0	0.0001	0.0001	0.0002	0.0002	0.0003	0.0005	0.0006	0.0008	0.001	0.0013	0.0016	0.0019	0.0023
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 24. Overlapping 75%; tau=0.0025 s.

n/r	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.005	0.0083	0.0125	0.0175	0.0234	0.0301	0.0376	0.0459	0.0551	0.0651	0.076	0.0877	0.1002	0.1136	0.1278
3	0	0	0	0	0	0.0001	0.0001	0.0001	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006
4	0	0	0	0	0	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001

Table 25. Overlapping 90%; tau=0.001 s.

n/r	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	0.002	0.0033	0.005	0.007	0.0094	0.0121	0.0151	0.0184	0.0221	0.0261	0.0305	0.0352	0.0402	0.0456	0.0513
3	0	0	0	0	0	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001
4	0	0	0	0	0	0	0	0	0	0	0	0.0001	0.0001	0.0001	0.0001

8 Conclusion

This work has documented the RMTK Noise Tool software with a brief walkthrough of software usage and output (Chapter 2), and has documented the scientific basis for the RMTK Noise Tool (Chapters 3-7).

This report documents the final state of the first version of the RMTK Noise Tool. Future work will include: 3D terrain capability, geographically-based regional weather, and small arms capability.

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Acronyms and Abbreviations

Term	Spellout
ANSI	American National Standards Institute
ATSC	Army Training Support Center
CALFEX	Combined Arms Live Fire Exercise
CERL	Construction Engineering Research Laboratory
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
CSEL	C-weighted Sound Exposure Level
DOD	Department of Defense
DODIC	Department of Defense identification code
EQT	Environmental Quality Technology
ERDC	Engineer Research and Development Center
ESRI	Environmental Systems Research Institute, Inc.
ETMP	Army EQT Management Plan
FDD	Functional Description Document
FFP	Fast Field Program
GIS	geographic information system
GUI	graphical user interface
HE	high explosive
ITAM	Integrated Training Area Management Program
MICLIC	Mine Clearing Line Charge
MLRS	Multiple Launch Rocket System
NSWC/DL	Naval Surface Warfare Center, Dahlgren, VA
RFMSS	Range Facility Management Support System
RMTK	Range Managers Toolkit
RONIP	Range Operators Noise Impact Predictor
RSC	Regional Support Center
RTLP	Range and Training Land Program
SARNAM™	Small Arms Range Noise Assessment Model
SDZ	surface danger zone
SEL	sound exposure level
SI	Systeme Internationale
SME	subject matter expert
SRP	Sustainable Range Program
TECOM	(U.S. Marine Corps) Training and Education Command (TECOM)
TM	(Army) Technical Manual
TNT	Trinitrotoluene
TOW	Tube-launched, Optically-tracked, Wire command-link guided Missile System (TOW)
URL	Universal Resource Locator
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine

Term	Spellout
USMC	U.S. Marine Corps
UWG	User Working Group (UWG)
WG	Working Group (WG)
WWW	World Wide Web

Appendix: RMTK Functional Description Document

An excerpt from the RMTK FDD concerning noise is included below:

A5.	Noise Tool	Fielded?
	a. The RMTK-Noise Tool will assist the user predict training noise, generated from weapon and demolitions. RMTK will assist the user in predicting potential noise synchronizing training requirements and identifying mitigation and education requirements for the public concerning training noise.	P
	b. The RMTK-Noise Tool will determine and display noise levels for specific weapon and vehicle systems on a range or training area in conjunction with a range of meteorological conditions on a case by case basis.	Y
	c. The RMTK-Noise Tool will provide the user the ability to forecast noise contours from scheduled facilities and allow the user to perform “what-if” scenarios, to include weather, when to shoot or mitigate.	Y
	d. The RMTK-Noise Tool will provide the capability to plan for CALFEX.	Y
A5.1.	Noise Tool Input	Fielded?
	a. The *RMTK Noise Tool* will allow the user to choose season, time of day, cloud cover, wind speed, wind direction, and terrain type. Weather options include a “worst case” condition.	Y
	b. The RMTK-Noise Tool will accept Digital Elevation Maps (DEM’s) to allow the user to account for terrain effects.	N
	c. The RMTK-Noise Tool will provide geographical region-specific weather conditions.	N
A5.2	Noise Tool Output	Fielded?
	a. The RMTK-Noise Tool will provide output which will be +/- 10 percent of BNOISE2 and SARNAM, given identical input and metric.	Y
	b. The RMTK-Noise Tool will display noise modeling output using a default standard color gradient, with break points at specific threshold values, but will allow the user to adjust threshold values. Default thresholds are weapons system class specific (examples: small arms, blast noise, or high performance).	Y

	c. The *RMTK Noise Tool* will have a graduated color bar with green indicating low risk and red indicating high risk. The colors will be anchored initially at 115 dB and 130 dB for large arms.	Y
	d. The RMTK-Noise Tool will allow the user to choose from several formats to output the noise information. These formats will be compatible with Range Facility Management Support System (RFMSS), Environmental Systems Research Institute, Inc. (ESRI) software, or text format that could be widely imported by other software suites.	N
A5.3.	Noise Tool Automation	Fielded?
	a. The RMTK-Noise Tool will receive and process automatic weather condition updates.	N
	b. The RMTK-Noise Tool will automatically update inputs in designated time sequence.	N
	c. The RMTK-Noise Tool will automatically display noise contours, allowing the user to view predictive models for planning purposes.	N

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14. ABSTRACT

The Range Managers Toolkit (RMTK) Noise Tool is a noise prediction and impact assessment software tool designed to enable installation Range Control offices to quickly assess the noise impact of military training or testing at a specified site under a variety of weather conditions, and to plan preliminary range siting for noise. The noise model outputs a map display that designates acoustic regions in decibels and by color. This work documents and summarizes the scientific basis for noise complaint risk criteria, weather cases, and time-on-target assessment.

15. SUBJECT TERMS
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